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Swift-Running Rivers Work Group Formal Reports Pertaining to Investigations and Analyses Performed Between June 1974 and August 1975

LT. JOHN T. TOZZI, U.S.C.G.

MAY 1976

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W. L. KING
Captain, U. S. Coast Guard
Chief, Environmental and
Transportation Technology Division
Office of Research and Development
U. S. Coast Guard
Washington, D. C. 20590

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16. Abstract

This report contains the two formal reports which were generated by the Swift-Running Rivers Work Group during its tenure, between June 1974 and August 1975. The Group was formed in response to a mandate from the Chief of Staff of the U.S. Coast Guard to investigate what appeared to be major aids-to-navigation problems in the Western Rivers System of the United States and to recommend a long-term R&D approach to their solution. The recommendations of the Work Group are stated explicitly in the first few pages of the Final Report of November 1975. Supporting information in the final report and the Work Group's Status Report of October 1974 are included under this cover for completeness and clarity.

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PREFACE

This report presents the recommendations of the Swift-Running Rivers Work Group concerning the most effective R&D approach to a long-term solution to aids-to-navigation problems in swift-running rivers. The Swift-Running Rivers Work Group was formed in June 1974 in response to a mandate from the Chief of Staff of the U. S. Coast Guard to investigate what appeared to be major aids-to-navigation problems in the Western River System of the United States and to recommend a long term R&D approach to their solution. The recommendations of the Group are based upon approximately three man-months of on-scene investigation and one man-month of data analysis, conducted during its year-long tenure.

Since the Work Group Status Report of October 1974 is referenced in the final report, it is included under this same cover. These two reports are the only formal reports which were generated by the group.

SWIFT-RUNNING RIVERS WORK GROUP

FINAL REPORT

November 1975

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INTRODUCTION

The Swift-Running Rivers Work Group was formed in June 1974 in response to G-CBU/84 memo 5930 dated 29 April 1974. Its expressed purpose was to recommend an R&D approach to a long-term solution to navigation in swift-running rivers. This report presents the recommendations of the group. The recommendations are based upon approximately three man-months of on-scene investigation and one man-month of data analysis, conducted during the year-long tenure of the group.

The work group members assigned by their respective commands were:

LT John Tozzi - G-DET; chairman CDR John Drewer - G-WAN LT Dan Ryan - CCGD2(oan)	Permanent members
LCDR Bob Cassis - G-DET LT Ted Colburn - R&DC LT Larry Olson - G-DST Mr. Paul Glahe - G-EOE Mr. Lowell Andrew - CCGD2(ecv)	Temporary members

The permanent members set and maintained the course of the group throughout the study. They requested assistance from the cognizant temporary member(s) in resolving problems related to specialized areas of expertise. Each member, permanent or temporary, was expected to spend about 20 percent of his work time on group business.

The main body of this report consists of a relatively short, concise statement of the group recommendations concerning R&D efforts in swift-running rivers navigation. Supporting information including a brief history of group activities over the past year and an explanation of the analytical techniques used and the results obtained are included in Appendices A through G.

RESULTS AND RECOMMENDATIONS

A. Results

According to the work group analysis of the navigation problems in swift-running rivers, the Coast Guard should direct its long-term R&D efforts in the area of river aids-to-navigation toward an improved short range aids-to-navigation (SRAN) system. As described in Appendix C, this system would consist of improved, lightweight fast water buoys, moorings, and shore structures; small, fast servicing craft; and improved servicing techniques. The analytical results presented in Appendix G show that, under the general assumptions made concerning implementation and cost considerations (some explained in Appendix F), the improved SRAN system does rate considerably higher than any of the other systems which were considered. Electronics systems rate well below the present SRAN system; the group's analysis indicates that these are impractical for river navaid use at this time. (This does not imply that the utility of electronics systems as river navaid systems should not be re-evaluated as the state-of-the-art improves. In fact, it is conceivable that periodic re-evaluations might show a favorable trend in the relative cost-effectiveness of such systems.) The interested reader will find further information concerning the conduct of the investigation and analysis in Appendices A through G.

B. Recommendations

Based upon the results of the work group's analysis, the following recommendations concerning the specific areas in which R&D efforts are required for the development of the improved SRAN system are made:

1. Improved, lightweight fast-water buoys:

   There is presently an R&D effort in this area. The Fast Water Buoy Development Project is scheduled for hand-off by 31 December 1976. Its product will be compatible with the concept of the improved SRAN system. Small design modifications may be required in order to place it in the improved system which is finally implemented; these modifications will require at worst a minimal effort on the part of Coast Guard engineers.

2. Improved, lightweight moorings (cable and anchor):

   Again, there is presently an R&D effort in this area. A modification of the specific areas of emphasis of the project work may be required to direct all or part of the result toward an acceptable lightweight river buoy mooring which is compatible with the improved SRAN system.

3. Improved, lightweight shore structures:

   An operating requirement to direct an R&D effort in this area should be developed. The improved structure should be compatible with the maintenance concept of the Improved SRAN System (Appendix C), i.e., the structure components and construction tools must be light and compact enough to be transportable by the developed small, fast servicing craft or a four-wheel drive vehicle of acceptable size and the structure should be easily assembled by two or three river AtoN servicing personnel.

4. <u>Small, fast servicing craft</u>:

An operating requirement to direct an R&D effort in this area should be developed. The required capabilities of the craft will be governed by its compatibility with the improved buoys, moorings, and structures and by the implementation plan which will be adopted, i.e., the number of craft which will be used, patrol frequency, etc. The satisfactory development of such a craft would necessarily be prefaced by a review of buoy, mooring, and structure servicing techniques which would enhance the servicing efficiency of the craft and its crew. The result of this review might be the identification of the need for an additional R&D effort to develop specialized handling equipment.

As the necessary operating requirements and implementation plans are developed, other areas requiring R&D assistance may be identified. In any event, the four areas discussed above are offered as a brcad basi~ for the total effort which should realize the full benefits of the Improved SRAN System within the next fifteen years.

A P P E N D I X   A

Work Group Activities, October 1974 - August 1975

This Appendix gives a synopsis of work group activities since the work group status report of October, 1974. As suggested in that status report, the work group effort was divided into three phases. These were:

1. Detailed orientation, systems research, and data collection

2. Data evaluation and correlation

3. Report preparation and presentation

Phase I was begun in October 1974 and extended through May 1975. During that time, the permanent members of the work group dedicated over three man-months to observation and data collection throughout the Second Coast Guard District. The Phase I Guide included as Appendix C of the status report of October 1974 was used to help channel the data collection effort into areas considered pertinent to the work group effort. The Phase I investigation helped the group members to become familiar with the river environment and yielded a large amount of documentation in the form of trip reports. These trip reports are presently held in a master file in G-DET-2; copies may be obtained upon request.

The work group began Phase II in June 1975. The first group meeting of Phase II was conducted at Coast Guard Headquarters, Washington, D.C., during the week of 22 June 1975. The agenda for the meeting called for a complete review of the group's position on towboat industry needs and the Coast Guard needs regarding river AtoN, of the possible alternate systems and system imprcvement listed in Appendix D of the status report of October 1974, and of desired river navaid system characteristics listed in Appendix D of that report in light of the knowledge gained during Phase I. The review was necessary in order to set a firm base for the system evaluation. Seven of the eight permanent and temporary group members were in attendance. The meeting produced rough drafts of the characteristics and classifications of river types, the classification of user types, system improvements or alternatives to be considered, the actual evaluation criteria to be used, and the procedure for the conduct of the evaluation. The final forms of the river characteristics and user types are included in Appendix B. The system improvements and alternatives considered are described in Appendix C. Appendix D shows evaluation criteria and Appendix E describes briefly the procedure for evaluation.

Only the permanent work group members participated in the final meeting held during the week of 27 July 1975. Copies of the contents of Appendices B, C, and D were distributed to each of the permanent members beforehand. During the meeting, implementation and cost considerations were formulated and the evaluation was conducted. Appendices E and F address specifically these items. Appendix G contains a synopsis of scoring and final results as presented in the body of the report.

APPENDIX B

River and User Classifications

River Classification

The Second Coast Guard District maintains aids to navigation on eight major rivers (Upper Mississippi, Lower Mississippi, Tennessee, Cumberland, Missouri, Arkansas, Illinois, and Ohio) and fourteen tributaries. There are 6232 total navigable river miles. In CY 73, 419,942,374 short tons of cargo transited parts of this river system for a total of 128.4 billion ton-miles. Table B-1 lists the major rivers and tributaries with their respective mileage and ton-miles (Statistics for CY 73).

For the purposes of this study, all eight major rivers and three Ohio River tributaries (Monongahela River, Green River, and Kanawha River) were considered. These rivers accounted for 99.8 percent of the total ton-miles during CY 73. They also comprise 90 percent of the river miles in the Western River System.

The rivers were grouped into three general classifications. These are open rivers, mixed rivers, and pooled rivers. The definitions of the open and pooled rivers were given in the work group status report of October 1974. The group considered it prudent to add the third classification, mixed rivers, to account for the problems peculiar to those rivers which are intended to be pooled but which have the characteristics of open rivers for more than three months each year when the forces of nature render the controlling functions of dams ineffective. The general basis for each classification is:

1. Open rivers - free flowing, no dam control

2. Mixed rivers - effective dam control for 50-90% of the year

3. Pooled rivers - effective dam control for 90% of the year or more

(Table B-2 lists major river-type characteristics)

The rivers were grouped as follows:

Open Rivers

1. Upper Mississippi River below St. Louis, Mo.

2. Lower Mississippi River

3. Missouri River

Mixed Rivers

1. Arkansas River

2. Ohio River below Newburgh, Ind.

3. Illinois River below Peoria, Ill.

Pooled Rivers

1. Tennessee River

2. Monongahela River

3. Cumberland River

4. Green River

5. Kanawha River

6. Upper Mississippi River above St. Louis, Mo.

7. Illinois River above Peoria, Ill.

User Classification

For the purpose of this study, the following classifications of river navaid users apply:

1. Large Users - commercial vessels which tow cargo barges or carry passengers in the inter-

port trade, no matter what the size of the vessel.

2. Small Users - Commercial vessels which tow cargo or service barges or carry passengers on an intra-port basis including fleeting tugs, excursion boats, and private pleasure craft.

RIVERS IN THE SECOND COAST GUARD DISTRICT

River	Miles	% Total Miles	Ton-Miles ($x 10^{-9}$)	% Total Ton-Miles
Mississippi (STL to Baton Rouge)	1139.9	18.3	69.7	54.3
Ohio	981	15.7	29.9	23.3
Mississippi (above STL)	673.5	10.8	10.7	8.3
Illinois	291	4.7	7.8	6.1
Tennessee	649	10.4	3.9	3.0
Monongahela	128.7	2.1	1.5	1.2
Green	103	1.7	1.4	1.1
Cumberland	381	6.1	1.1	.9
Missouri	732.6	11.8	.88	.7
Kanawha	91	1.5	.80	.6
Arkansas	447.6	7.2	.34	.3
Total	5618.3	90.3	128.02	99.8
Black-Ouachita	304		.11	
Allegheny	72.0		.08	
Minnesota	14.7		.06	
Kentucky	89.6		.05	
St. Croix	23.3		.03	
Big Sandy	4.0		.004	
Total	6125.9		128.4	

No Ton-Mile figures available:

Sans Bois Creek	-	10.9
Clinch	-	61.5
Emory	-	12.1
Little	-	1.2
Hiwassee	-	20.4
Total	-	106.1

TOTAL RIVER MILES: 6232

Source: Waterway Commerce of the U.S. CY 1973
Compiled by Lower Mississippi Valley Corps of Engineers

Definition: Ton mile figures reflect only the distance each ton of cargo moved on the waterway.

TABLE B-1

	OPEN	MIXED	POOLED
Current Range (mph)	Range: 3-8; Avg: 5	Range: 1-7; Avg:3	Range: 1-7; Avg: 1-2
Channel Stability	constantly shifting with some seasonal patterns	must be redefined before each pool stage (1-3 times per year)	stable
Channel Depth	seasonal variation, 9-40 ft.; higher frequency change due to weather, 5-20 ft.	seasonal variation, 9-40 ft. from pooled to open; higher frequency variation at high water, 5-20 ft.	Seasonal variation, 9-40 ft; higher frequency variation of about 10 ft.
Channel Width	Avg. width 300 ft. Varies seasonally; can be as wide as 600 ft. or as narrow as 150 ft.	Avg. width 300 ft. Varies seasonally; can be as wide as 600 ft. or as narrow as 150 ft.	Avg. width 300 ft. Little variation except at extreme high water.

TABLE B-2

APPENDIX C

Systems Evaluated

This Appendix contains an explanation of each system alternative or improved system considered during the work group analysis. The five systems which were rated against the present system were developed from the listing of possible alternative systems or system improvements contained in Appendix C of the work group status report of October 1974.

ELECTRONICS SYSTEM A

A. Principle of Operation

Electronics System A is an electronics navigation system which does require a compatible data processing capability aboard the user vessels. In general, the vessel will be provided information concerning the location of all navigable water with respect to a standard reference grid. A system will be supplied to permit any properly-equipped vessel to determine its position with respect to the reference grid. Channel and vessel position information will be inputs to an on-board processor which will provide usable navigation information to a suitable display console. The navigator will use the displayed information together with radar, bridge-to-bridge communications, fathometer, etc., to navigate safely.

B. Conceptual Systems

In general, Electronics System A requires five coordinated functions for proper operation. These are (1) the determination of all navigable water with respect to the standard grid, (2) the determination of the vessel position with respect to the grid, (3) the storage of updated channel information, (4) the transmission of all necessary data to the vessel at the appropriate time, and (5) the compilation and display of the data for the use of the navigator. Two conceptual systems which can fulfill these requirements are described below. It must be emphasized that these are conceptual systems and are not intended to represent a complete listing of feasible systems.

1. Loran-C System

Aircraft or high speed watercraft would be used to update channel information at suitable intervals. The vessels might employ highly accurate fathometers, sidescan sonars, or high resolution radar to determine the bottom depth profile; the survey craft's position at any given instant of time would be determined using a differential Loran-C technique. Depth and position information would be transmitted to and stored in a number of carefully positioned information transponders located along the river bank. As a tow progressed through a particular area, its navigation information system would interrogate the appropriate transponder to obtain updated channel information. Concurrently, its differential Loran-C positioning system would continuously update the vessel position information. (NOTE: On the larger tows, it would be necessary to know the position of both the head and the stern.) The channel and vessel position, orientation, and movement information would be processed and displayed for the navigator's use.

Complete implementation would require:

a. from the Coast Guard

i. a differential Loran-C system with suitable accuracy for each river.

ii. depth sounding craft with sufficient equipment to determine the bottom profile continuously while underway and some means of relating the depth at a certain point to Loran-C fix information.

iii. transponder - type data storage facilities for channel information at suitable locations along the river.

b. from the user

i. a sufficient number of Loran-C receivers and other necessary equipment to determine position and orientation (if necessary) sing differential Loran-C.

ii. interrogators and receivers to obtain current channel information.

iii. suitable data processing equipment to combine vessel position and channel information and produce a usable display.

iv. suitable collision avoidance equipment, e.g., radar and bridge-to-bridge radio.

2. Radar Positioning System

The same type of channel survey craft and survey equipment might be employed; however, the position of the craft at any time would be determined using the installed radar ranging system. This system would include coded or otherwise defined radar targets installed at appropriate locations along the river whose geographical position is known in some frame at reference. To determine vessel position, data processing equipment aboard the vessel would be provided the locations of two targets which would be used, the range of the vessel from each target, and the LOP crossing angle at the vessel by a calibrated, high resolution radar. As the vessel progressed on its journey, radar target position would be updated when necessary. The range of the vessel from each target and the LOP crossing angle would be updated on a continuous basis. Using this positioning method, then, and the installed depth sounding equipment, the survey craft could rapidly update the depth and position information stored in the same type of carefully positioned information transponders as suggested for the Loran-C system. As a tow transited an area, its navigation system would interrogate the appropriate transponder to obtain updated channel information. Concurrently, the radar positioning system would continuously update the vessel position information. (NOTE: On larger tows, an identifiable radar reflector placed on a lead barge could be used to obtain orientation information.) The channel and vessel position (and orientation) information would be processed and displayed for the navigators' use.

Complete implementation would require:

a. from the Coast Guard

i. a sufficient number of radar targets placed in suitable positions along the river.

ii. depth sounding craft with sufficient equipment to determine the bottom profile continuously and some means of relating a depth at a certain point to radar fix information.

iii. transponder-type data storage facilities for channel information at suitable locations along the river.

b. from the user

i. a calibrated, high-resolution radar and other necessary equipment to determine position and orientation (if necessary) using the radar positioning system.

ii. interrogators and receivers to obtain current channel information.

iii. suitable data processing equipment to combine vessel position and channel information and produce a usable display.

iv. some means of checking and adjusting, if necessary, the calibration of the radar at frequent intervals while underway.

v. suitable collision avoidance equipment, e.g., bridge-to-bridge radio.

ELECTRONICS SYSTEM B

A. Principle of Operation

Electronics System B is an electronic navigation system which does not require a data processing capability aboard the user vessels. In general vessel position, orientation, etc., are monitored by some suitable means from several carefully positioned sites along the river. Bottom profile data in its area of coverage is transmitted to each shore site at frequent intervals. The channel and vessel position information is processed at each shore site and the processed data is transmitted to the user vessels in the area for display. The navigator will use the displayed data together with a back-up radar, bridge-to-bridge communications, fathometer, etc., to navigate safely.

B. Conceptual System

In general, Electronics System B requires five coordinated functions for proper operation. These are (1) the determination of all navigable water with respect to a standard grid, (2) the determination of the vessel position with respect to the grid, (3) transmission or compilation of the necessary data at each shore site, (4) processing the data at the shore site, and (5) transmission of the processed data to user vessels and display. Two conceptual systems which can fulfill these requirements are described below. Again, it should be noted that these conceptual systems are not intended to represent a complete listing of feasible systems.

1. Shore-Based Radar System

Shore sites equipped with high resolution radars would be constructed at suitable intervals along the river. The exact geographical position of the radar would be known in some frame of reference. Consequently, the position of any location within the area of coverage of the radar would be known. As vessels entered the area of coverage of a particular site, they would shift their information data receivers to the appropriate site. Their positions relative to the radar would be determined at the shore site and provided as an input to the shore-based data processing equipment. Further, a channel survey craft, similiar to those suggested previously, would provide updated channel information to the data processor at frequent intervals. Note that the position of the channel survey craft, if waterborne, would be known at all times since it would be a radar contact. Consequently, no other positioning system is necessary aboard a waterborne survey craft. Further, if a compatible display system is installed on a waterborne survey craft, the personnel aboard it could see the channel information change as they transmit the updated data to the system. Orientation of the larger tows could be obtained directly from the radar image. The channel and vessel position, orientation, and movement data would be processed at each shore site and transmitted to the user vessels in the area for display.

Complete implementation would require:

a. from the Coast Guard

i. a suitable number of radar-equipped shore sites with rapid data processing equipment on each river.

ii. a depth sounding craft with sufficient equipment to determine the bottom profile continuously while underway and equipped with a compatible data display system.

b. from the user

i. receivers and a compatible data display system.

ii. back-up collision avoidance equipment, e.g., radar and bridge-to-bridge radio.

2. Loran-C System

Shore sites would be constructed as before; however, since they would have no direct radar positioning function, their locations would be less critical. Also, their number might be reduced significantly. Each vessel transiting an area would be equipped with one (or two, if orientation is desired) Loran-C receivers which would obtain position information continuously from an installed differential Loran-C system which would cover the particular area. This information would be transmitted immediately to the currently "local" shore site. Channel information would be provided to each shore site by a high speed survey craft which would also use the differential Loran-C system to determine its position. The vessel and channel information would be processed at the appropriate shore site and transmitted to the user vessels in the area for display.

Complete implementation would require:

a. from the Coast Guard

i. a suitable number of shore sites with transmitters, receivers, and rapid data processing equipment on each river.

ii. a differential Loran-C system with suitable accuracy for each river.

iii. depth sounding craft with sufficient equipment to determine the bottom profile continuously while underway and some means of relating a depth at a certain location to Loran-C fix information.

b. from the user

i. Loran-C receiver(s) and necessary transmitting equipment to determine and transmit position (and orientation, if necessary) information to "local" shore site.

ii. receivers and a compatible data display system.

iii. back-up collision avoidance equipment, e.g., radar and bridge-to-bridge radio.

PRESENT SHORT-RANGE AtoN (SRAN) SYSTEM

A. Principle of Operation

The present AtoN system maintained on the Western Rivers is a buoy-beacon type of system which, if properly maintained, offers, during periods of slow to moderate current speed, a good visual navaid capability in clear weather and a limited radar navaid capability in foul weather. Effective service may not be provided either visually or by radar during periods of high current speed since the floating aids are submerged. It requires only basic collision avoidance equipment to be provided by the user (radar, bridge-to-bridge radio). In general, the user vessels are provided visual and limited radar information concerning the location of a navigable channel in which water depths are greater than some published lower limit. Since the channel markers are maintained by a slow waterborne vessel, system adjustments due to changing river bottom contours and river levels are made on a systematically scheduled basis. Fast reaction to a particular problem in a certain area cannot be expected. Consequently, navigation charts, written and broadcast channel reports, and river stage predictions are offered to the user to supplement the maintained system. Note that the navigation charts also enhance the predictability of forthcoming problems. The navigator mentally combines all of the available navigation information from the navaid system with his own experience to make the best navigational decisions.

B. System Maintenance

As described above, the system utilizes basically visual AtoN equipment to provide a complete visual and a very limited radar navaid system. The buoy systems used are buoy-mooring cable-concrete sinker (in a few cases, jetted cone). The beacons are constructed or attached to trees along the river banks. The servicing craft are of the pusher-barge type. They are relatively slow and service the aids in their area of responsibility on a scheduled basis. During an AtoN patrol, the servicing craft adjusts the buoys and beacons to account for a changing bottom contour; corrects discrepancies caused by fast current, debris, or towboat collisions; and retrieves stray buoys or damaged structures. All hardware replacement is effected through the district office on competitive contracts.

Complete implementation requires:

a. from the Coast Guard

i. hardware including buoys, beacons, light systems, etc.

ii. servicing craft and personnel.

iii. channel reports (written and broadcasted).

iv. support units, e.g., depots, group personnel, buoy tender moorings, etc.

b. from the user

i. some experience on the river.

ii. collision avoidance equipment, e.g., radar and bridge-to-bridge radio.

c. from the U. S. Army Corps of Engineers

i. navigation charts.

ii. river level predictions.

IMPROVED SHORT-RANGE AtoN SYSTEM

A. Principle of Operation

Essentially the same as the Present System with the following improvements:

1. Improved buoys to minimize fast current-caused discrepancies, thus providing better service during periods of fast current.

2. Improved buoy mooring systems to permit servicing by smaller, faster craft.

3. Small, fast servicing craft, capable of quick reaction to reported discrepancies as well as frequent, fast inspection and routine maintenance patrols.

4. Improved servicing techniques which facilitate both routine and non-routine servicing operations.

5. Improved methods for marking bridge piers and other such obstructions, e.g., RACONS, coded radar, reflectors, etc.

This system extends the effectiveness of the present system to periods of high current speed, and it increases the overall present system effectiveness by reducing response time and service time.

B. Conceptual System

The conceptual system would utilize buoys and beacons as its primary means of providing navigational information.

However, the buoy/mooring systems would be light weight and very efficient in the river environment. The beacons would be redesigned to lessen the weight and to accelerate the required installation procedure. The servicing craft would be small, high speed craft manned by about 4-5 people. The areas of responsibility of the servicing craft would be apportioned to insure that each craft would be placed near the middle of its run and that each craft could inspect one-half of its run in 12 hours or less. One or two large tenders may be retained in each major river to perform the more difficult tasks and to resupply the small AtoN craft. Whenever possible, beacons would be serviced by use of a four-wheel drive vehicle assigned to each small AtoN craft. The user is offered a system of visual aids with supplementary navigation charts, channel reports, and river stage predictions. He combines the available navigational information with his own experience and his collision avoidance information to make navigational decisions.

Complete implementation would require:

a. from the Coast Guard

i. improved river AtoN hardware including buoys, moorings, beacons, etc.

ii. sufficient small, high speed servicing craft to support the system in a manner consistent with the fast-reaction discrepancy-correction concept.

iii. sufficient large servicing craft to handle the "big jobs" and to resupply the small craft.

iv. support units, e.g., depots, group personnel, moorings, etc.

v. channel reports (written or broadcasted)

b. from the user

i. some experience on the river.

ii. collision avoidance equipment, e.g., radar and bridge-to-bridge radio.

c. from the U. S. Army Corps of Engineers

i. navigation charts.

ii. river level predictions.

HYBRID SYSTEM A

A. Principle of Operation

This system combines Electronics System A and the Improved Short-Range AtoN System to form one system which provides more satisfactory service to the small user (see Appendix B) while offering suitable degree of redundancy for the large user in the event of a total primary system failure. Buoy or beacon adjustments for shifting channels could be made using the electronics system channel information. In fact, the channel survey craft could double as an SRAN tending craft. A complete improved SRAN system would be maintained in designated ports; a minimum improved SRAN system would be maintained between ports to permit vessels to travel at reduced speed with some increased risk of grounding if the primary system fails.

Complete implementation would require:

a. from the Coast Guard

   i. combined items listed for the individual systems.

b. from the user

   i. from the large user - combined items listed for the individual systems.

   ii. from the small user - only those items listed under Improved SRAN System.

HYBRID SYSTEM B

A. Principle of Operation

This system combines Electronics System B and the Improved Short-Range AtoN System to form one system which provides more satisfactory service to the small user while offering a suitable degree of redundancy for the large user in the event of total primary system failure. Buoy or beacon adjustments for shifting channels could be made using the electronics system channel information. In fact, the channel survey craft could be double as a buoy-beacon tending craft. A complete improved SRAN system would be maintained in designated ports; a minimum improved SRAN system would be maintained between ports to permit vessels to travel at reduced speed with some increased risk of grounding if the primary system fails.

Complete implementation would require:

a. from the Coast Guard

i. combined items listed for the individual systems.

b. from the user

i. from the larger user - combined items listed for the individual systems.

ii. from the small user - only those items listed under Improved SRAN Systems.

APPENDIX D

Evaluation Criteria

This Appendix contains the evaluation booklet which was used by the permanent group members to evaluate the proposed system alternatives/improvements against the present system. Many of the rating points required subjective decisions to be made concerning implementation and cost considerations. The group made these decisions using available information; some of the considerations which directed the ratings are contained in Appendix F. The actual evaluation sheets for each system are on file in the work group file in G-DET-2.

Some general considerations which governed the developments of the evaluation booklet were:

1. Both effectiveness and cost criteria must be considered. Part I is essentially effectiveness criteria while Part II relates to cost.
2. The number ' d arrangement of the individual rating items ' ould be selected so that the relative importance of each item is reflected in the final result. This led to the development of definite sections within each part (cost and effectiveness), containing only a few rating items each and weighted as to importance.
3. The actual number rating system used should not permit "average" ratings and should provide for adequate differences between number grades. Consequently, the system of 0, 1, 7, 10 was selected to meet these requirements.

4. The evaluation procedure should permit as much flexibility as possible in rating the relative importance of cost and effectiveness so that sensitivity analyses can be performed and, if necessary, the weighting of each can be changed in light of changing management philosophy.

RIVER NAVAID SYSTEMS EVALUATION

System______________________________

Evaluator______________________________

River Classification______________

This evaluation booklet provides a means by which selected river navaid systems can be rated on a relative basis. The product of the evaluation will be a numerical grade which reflects the overall relative suitability of a given system when compared to its competitors. In order to perform the evaluation, the evaluator must rate the system on each of the rating items suggested in the four sections of Part I and the two sections of Part II. For the purposes of the rating,

- 0 - no capability/effect at all
- 1 - poor
- 4 - fair
- 7 - good
- 10 - excellent

The evaluator should total the raw score upon completion of each section. Note that the weight of each section within both Parts I and II is provided with the section title for the information of the evaluator. Comments on the specific strenghts and weaknesses of the system are solicited at the conclusion of each section. The evaluator is encouraged to offer specific comments on all items, particularly those for which the system received a rating of 0.

Synopsis-of-scoring sheets for Parts I and II and an overall synopsis-of-scoring sheet is provided with this booklet. Upon completion of Parts I and II, the evaluator should record the pertinent information on the appropriate synopsis-of-scoring sheet. The overall score is determined by combining the scores for Parts I and II in the overall synopsis-of-scoring, after weightings for Parts I and II are set.

PART I - SYSTEM PERFORMANCE AND USER ACCEPTANCE CRITERIA

A. ADEQUACY (40%)

	RATING (0,1,4,7,10)
1. Identifies navigable water (assuming the maximum practical survey frequency)...............	________
2. Provides vessel position and orientation within the navigable water.........................	________
3. Provides information concerning the rate of change of vessel position and orientation within the navigable water.........................	________
4. Provides a predictability capability to insure that the vessel operator will have sufficient advance information.......................	________
5. Provides the required information in a suitable format to insure that it can be easily assimilated by the user....................	________
TOTAL RAW SCORE........	________

Comments on strengths and weaknessess (continue on reverse side if necessary)

B. FLEXIBILITY (10%)

RATING
(0,1,4,7,10)

1. Adjusts rapidly for changing water levels......__________

2. Adjusts rapidly for shifting channels..........__________

3. Permits safe navigation under all weather conditions, day or night...........................__________

TOTAL RAW SCORE........__________

Comments on strengths and weaknesses (continue on reverse side if necessary)

C. AVAILABILITY (20%)

RATING (0,1,4,7,10)

1. Insensitive to the hazards of the river environment including swift current, debris, towboat collisions, vandalism, bank erosion, and ice (if appropriate).......................... __________

2. Provides sufficient reliability and redundancy to insure that usable time will be maximized and that back-up systems will permit all user vessels to at least travel at reduced speed and at increased but acceptable risk during primary system outage.. __________

3. Short mean time to repair.................... __________

TOTAL RAW SCORE....... __________

Comments on strengths and weaknesses (continue on reverse side if necessary)

D. ACCEPTABILITY TO THE USER
(assuming voluntary user acceptance) (30%)

	RATING (0,1,4,7,10) Large User	Small User
1. Low total system cost............	________	________
2. Minimum transition impact........	________	________
TOTAL RAW SCORE........	________	________

Comments on strengths and weaknesses (continue on reverse side if necessary)

SYNOPSIS OF SCORING

PART I

SECTION A

Raw Score = ________

Normalized Weighted Score = $\frac{\text{Raw Score}}{50}$ x 100 x .40 = ________

SECTION B

Raw Score = ________

Normalized Weighted Score = $\frac{\text{Raw Score}}{30}$ x 100 x .10 = ________

SECTION C

Raw Score = ________

Normalized Weighted Score = $\frac{\text{Raw Score}}{30}$ x 100 x .20 = ________

SECTION D

Raw Score = ________ Large User

________ Small User

		Large User	Small User
Normalized Weighted Score = $\frac{\text{Raw Score}}{20}$ x 100 x .30	=	____	____
TOTAL NORMALIZED WEIGHTED SCORE...	=	____	____

PART II - COAST GUARD ASPECTS

A. IMPLEMENTATION PLAN (40%)

	RATING (0,1,4,7,10)
1. Low initial cost	________
2. Minimum workload impact	________
3. Minimum transition impact	________
TOTAL RAW SCORE	________

Comments on strengths and weaknesses (continue on reverse side if necessary)

B. LOGISTICS (60%)

	RATING (0,1,4,7,10)
1. Ease of maintenance...........................	________
2. Reasonable personnel training level required for maintenance..........................	________
3. Reasonable type and size of servicing craft required....................................	________
4. Low cost of maintenance.......................	________
TOTAL RAW SCORE.......	________

Comments on strengths and weaknesses (continue on reverse side if necessary)

SYNOPSIS OF SCORING

PART II

SECTION A

Raw Score = __________

Normalized Weighted Score = $\frac{\text{Raw Score}}{30} \times 100 \times .40$ = __________

SECTION B

Raw Score = __________

Normalized Weighted Score = $\frac{\text{Raw Score}}{40} \times 100 \times .60$ = __________

TOTAL NORMALIZED WEIGHTED SCORE...... = __________

OVERALL SYNOPSIS OF SCORING

A. TOTAL NORMALIZED WEIGHTED SCORES

Part	Large User	Small User
I		
II		

B. OVERALL SCORES

Weighting Factors		Overall Scores*	
Part I	Part II	Large Users	Small Users

*Overall Score = $(\text{Total Score} \times \text{Weighting Factor})_{\text{part 1}}$

$+ (\text{Total Score} \times \text{Weighting Factor})_{\text{part 2}}$

A P P E N D I X   E

Conduct of the Evaluation

The three permanent work group members conducted the evaluation of the proposed systems alternatives and improvements during the week of 27 July 1975. At that time the implementation and cost considerations, some of which are included in Appendix F, were developed; and, based on these and other calculated assumptions, the evaluation was performed. The initial intent was to perform a separate evaluation for each river type, but the results for the open and pooled rivers showed the same trends so that a separate evaluation for the mixed rivers was deemed unnecessary. A synopsis of scoring for the open and pooled rivers is illustrated in Appendix G. After the actual rating was completed, the group performed a sensitivity analysis on the results for different cost and effectiveness weightings. The results of these analyses are presented also in Appendix G and support well the final results and recommendations.

A P P E N D I X   F

Implementation and Cost Considerations

As the permanent work group members began the evaluation of the system alternatives and the improved system, it became apparent that assumptions concerning implementation and cost considerations would be required in order to rate some of the items. Some of the assumptions are indicated explicity in the evaluation booklet, e.g., item I.A.1. requires a rating for the degree to which a particular system identifies the available navigable water under the explicit assumption that the maximum practical channel survey frequency for the available survey craft is used and section I.D. requires a rating of two items concerning the acceptability of the system to the user under the explicit assumption the user has a choice of any of the systems considered. However, many more implicit assumptions concerning other rating items were made. All assumptions were made in light of the best available information from personnel with expertise in the particular area. The purpose of this appendix is to point out some typical implicit assumptions made in order to illustrate the general line of reasoning used in most cases. Specifically, the assumptions made during the rating of item I.A.5. and II.B.4. are presented.

A. Assumptions Made During the Rating of Item I.A.5.

Item I.A.5. requires a rating on the suitability of the format of the navigational information presentation for easy assimilation by the user. The group agreed that, from their observations during the data gathering phase (Phase I), the present system (assuming that all buoys and shore aids are properly placed and on station) offers a sufficient amount of navigation information for safe navigation in a very satisfactory format. In general, the short range aids to navigation system offers, during periods of good visibility, information from three sources: (1) visual observation of the aids on station and other river traffic in the area, (2) Corps of Engineers navigation charts, and (3) Coast Guard written or broadcasted channel reports. During periods of reduced visibility, the radar display will either supplement or replace the visual observations. From this information, the operator can (1) determine his vessel's position in the channel, (2) determine the position of other vessels in his area relative to his own position and relative to the channel, (3) predict the change in his vessel's position with time with respect to the channel and other vessel's in the area, and (4) predict and prepare for hazards or otherwise undesirable situations which might be upcoming within at least one mile of the present position of his vessel. Discussions with towboat operators indicate that this format of navigation information presentation is very satisfactory. Consequently, the group assigned a rating of 10 for item I.A.5. for systems which provided information in the same or a very similar format.

In considering the method by which the electronics systems could be rated relatively on this item, the group considered first the impact of the required electronics display. Since the SRAN system offers the operator both along-track and cross-track information to the same scale, this was imposed as a requirement for the electronics display. Further, a minimum of 1 mile along-track predictability is required to offer information to the same standard as the present system; and, in order for the operator to safely place a tow which may exceed 100' in width in a channel 300' wide, the 300' channel width should approach 2½" on a display screen. Consequently, a screen width of 10" (to allow for variations) would suffice. However, the minimum screen length (for the same scale) would have to be 44", calculated in the following manner:

$$\frac{2.5}{x} = \frac{300}{5280}$$

$$x = 44''$$

Under the preceding assumptions, the practical use of Electronics System A during periods of good visibility (assuming perfect accuracy of the positioning system) would require that the operator receive information from two sources: (1) the rather large electronics display, and (2) visual observations of other vessels in his area. But the coordination of the information from these sources would be very difficult and could prove almost impossible in pressure situations. Further, the use of the radar to supplement or replace the visual observations during periods of reduced visibility would be very awkward and, in fact, probably unacceptable. Consequently, the Electronics System A was rated 4 on item I.A.5.

In like manner, the group considered the relative suitability of Electronics System B, the Improved SRAN System, and the Hybrid Systems. The result was the following rating pattern on Item I.A.3.:

System	Rating (open & pooled rivers)
Electronics A	4
Electronics B	7
Present	10
Improved SRAN	10
Hybrid A	7
Hybrid B	10

B. Assumptions Made During the Rating of Item II.B.4.

Item II.B.4. requires the rating of the cost of maintenance of each system (from the Coast Guard standpoint). Such judgments require many assumptions concerning the required hardware, facilities, and personnel for system maintenance as well as the annual cost of each. The group decided that the logical evaluation of the systems on this item would require the following guidelines:

1. All costing would be done based on available present-day statistics for comparable support components. If a particular system required a support component for which no statistics are presently available (this did turn out to be a rare exception), a best guess would be made.
2. Maintenance costs would be compared on an annual basis.

3. All support components would be assumed to be dedicated to the river aids-to-navigation system, i.e., no shared costs with other Coast Guard functions would be considered.

Although it is impractical to include in this appendix the implementation and cost considerations for all of the candidate systems, the assumptions made for Electronics System A on the open rivers are presented as an example of the logic used in one case.

Electronics System A - Open Rivers

Based upon information obtained from various electronics-oriented personnel, the work group assumed that effective implementation of the LORAN-C-type system would require the maintenance of at least three LORAN-C stations in order to cover adequately the open rivers. Current inland LORAN-C station annual maintenance costs indicate that an annual cost of $300,000/Station is reasonable. The system on the open rivers would require a total of about 9 servicing and survey vessels (based on river miles) at $50,000/year/craft. Further, approximately 12 transponders at $10,000/year/transponders, six dedicated maintenance personnel (not including LORAN station personnel) at $10,000/year/person, and three support depots for the servicing and survey craft and personnel at $50,000/year/depot would be required. Consequently, the approximate annual maintenance cost if the LORAN-C type system was used on the open rivers would break down as follows:

LORAN-C Stations	3 x $300,000 =	$ 900,000
Service & Survey craft	9 x $ 50,000 =	$ 450,000
Transponders	12 x $ 10,000 =	$ 120,000
Personnel	6 x $ 10,000 =	$ 60,000
Support Depots	3 x $ 50,000 =	$ 150,000
Total (annual)		$1,680,000

The group reasoned that, if the radar-type system was used, the maintenance cost of radar stations would approximately offset that of the LORAN Stations so that the annual maintenance cost for Electronics System A was assumed to be $1,680,000 no matter which type of system was used.

Similar logic was used to estimate the annual maintenance costs of each system for both the open and pooled rivers. The analysis yielded the following relative rating pattern for item II.B.4. (the lowest annual maintenance cost forced a rating of 10):

	Rating	
System	Open Rivers	Pooled Rivers
Electronics A	7	7
Electronics B	4	4
Present	4	7
Improved SRAN	10	10
Hybrid A	4	7
Hybrid B	1	4

A P P E N D I X   G

Synopsis of Results

This Appendix illustrates in graphical form the results of the system evaluation for both the open and the pooled rivers. The results of three analyses performed with different hypothetical weightings for cost criteria and effectiveness criteria are shown. Note that for each case considered, the solid lines represent the results for the large user and the dashed lines represent those for the small user. Where only a solid line can be seen, the results coincide.

The presentation shows clearly the logic of the final recommendations of the group in light of these results. The numerical rating for the Improved SRAN System in any case is approached closely only by the rating for the Hybrid Systems for the small user when effectiveness and cost are rated 75 percent and 25 percent respectively. However, even in this case, the ratings for the Hybrid Systems for the large user are still well below that for the Improved SRAN System. Clearly, under the assumptions and evaluation criteria used in this analysis, the Improved SRAN System is the most cost effective overall.

In order to enhance the legibility of the graphical presentations which follow, symbols were used to represent the competing navaid systems. These are indexed as follows:

A - Electronics System A	I - Improved SRAN System
B - Electronics System B	HA - Hybrid System A
P - Present SRAN System	HB - Hybrid System B

OPEN RIVERS

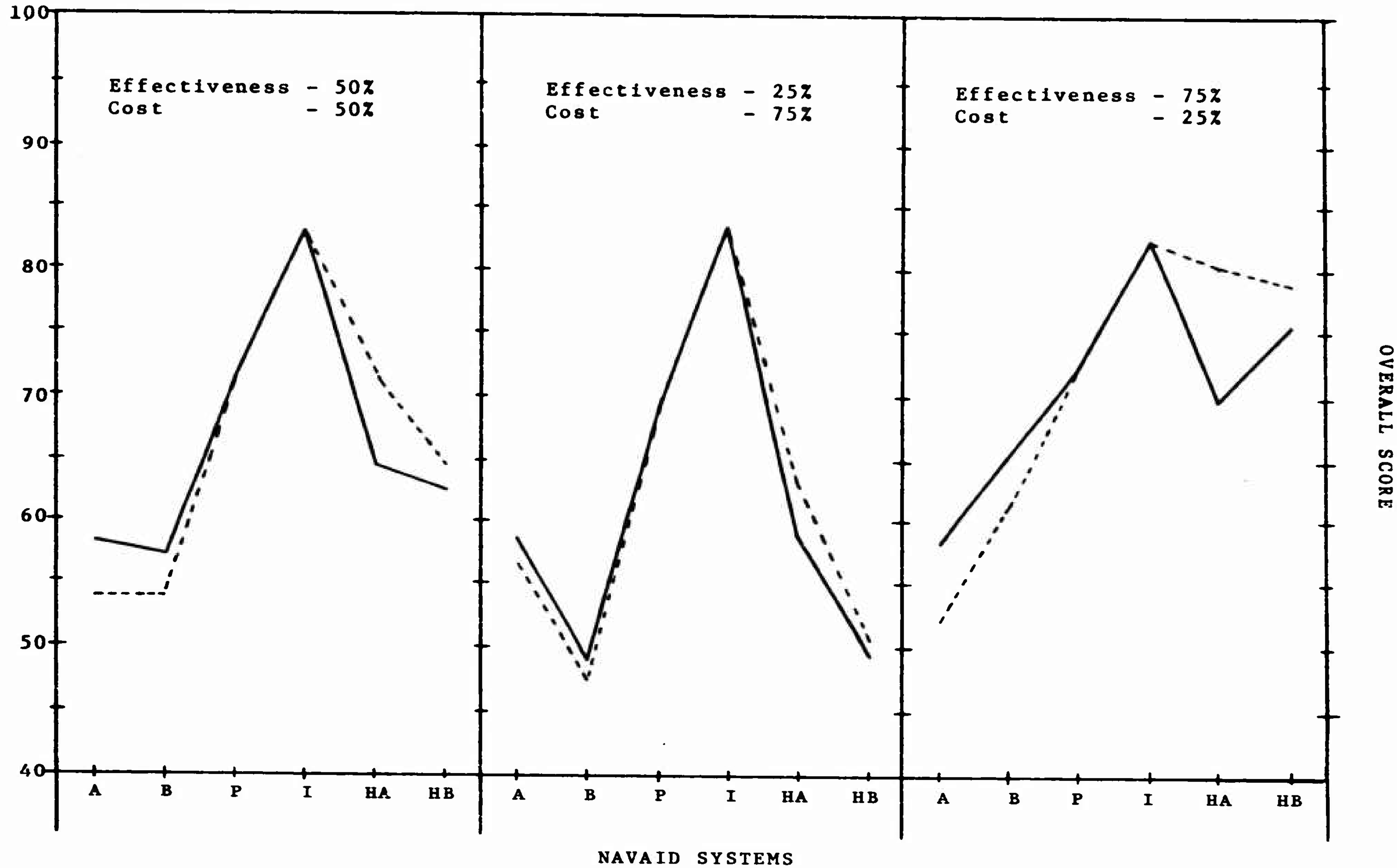
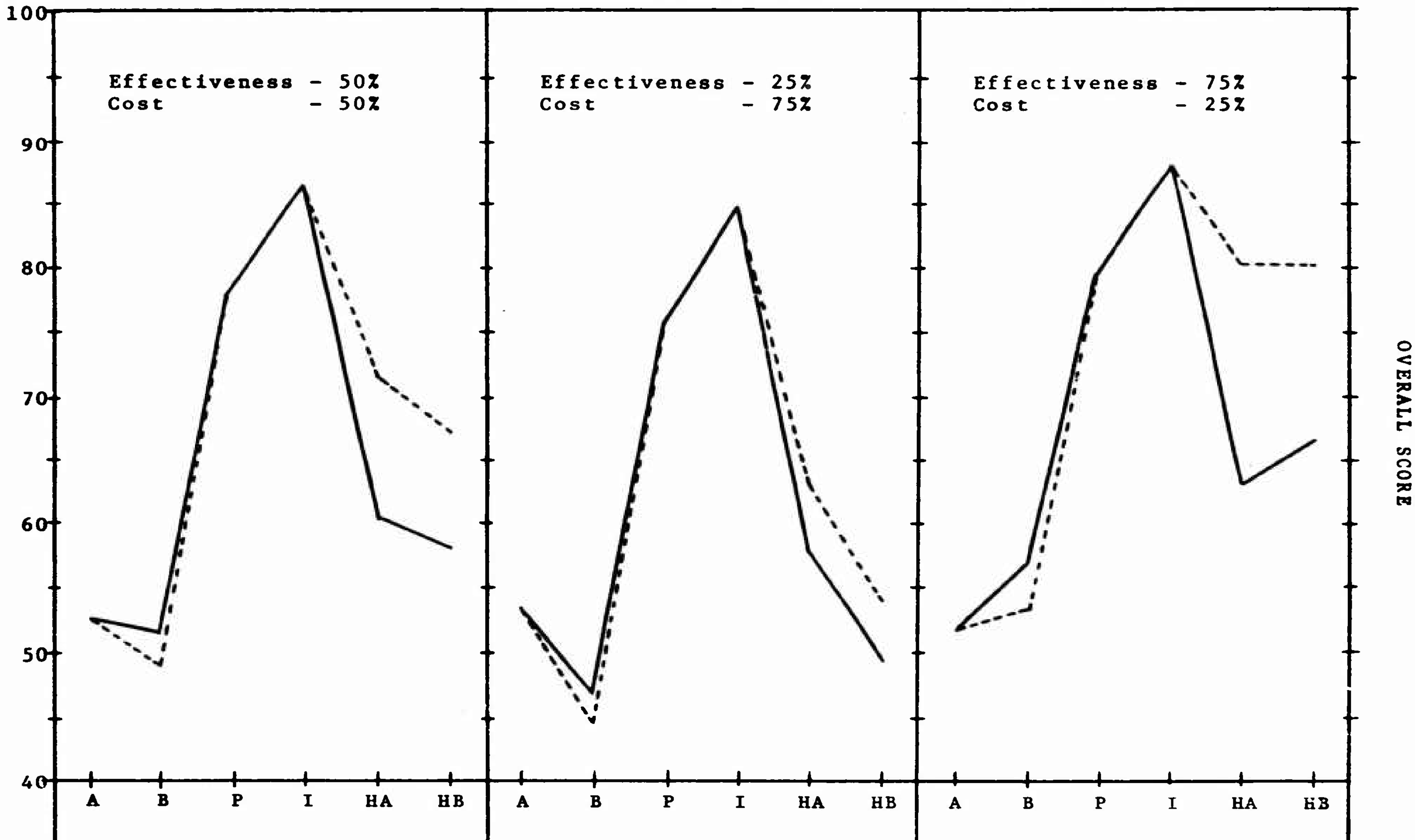


Fig. G-1

POOLED RIVERS



NAVAID SYSTEMS

Fig. G-2

SWIFT - RUNNING RIVERS WORK GROUP

STATUS REPORT

OCTOBER 1974

SUMMARY

The Swift-Running Rivers Work Group was formed in response to G-CBU/84 memo 5930 dtd 29 April 1974 (in Appendix A). Its purpose is to develop an R & D approach to a long-term solution to navigation in swift-running rivers. The group consists of permanent members from G-WAN, G-DET, and CCGD2 (oan); temporary members with expertise in specific areas of interest are requested as the need arises.

A concise statement of the problem(s) in navigating (or providing adequate Aids to Navigation service) on swift-running rivers is difficult, if not impossible. The symptoms of the problem(s) include:

(a) Upwards of 53% average buoy losses per annum on the Western Rivers. Average buoy losses on particular rivers can exceed 100% per annum. A large number of buoys lost implies a large number of aid discrepancies throughout the system. These discrepancies undermine the basic function of the aid system and increase its maintenance costs greatly.

(b) Excessive workloads for Aids to Navigation servicing craft (WLR's) which correct Aids to Navigation discrepancies and modify the system to enhance navigation during all river conditions. The duty cycle for the tenders is governed almost solely by the expected buoy losses.

(c) Extreme sensitivity of the system to changes in the economic climate. Unpredictable inflation causes periods of reduced service due to funding shortages. Yet, the large consolidated tows transiting the Western Rivers nowadays require a high degree of navigational accuracy. At times, there is a disparity between required and provided service.

The identification of these symptoms as true problems is premature since, at present, there is no mechanism for collecting and analyzing river buoy loss information for the determination of system performance. System studies are needed to evaluate the impact of each symptom on the cost-effectiveness of the system.

For the purposes of this study, the work group will assume that there are identified problems which require the consideration of system improvements and alternatives. The approach which will be taken is to meld all possible solutions against the desired system characteristics. In this way, any number of systems can be evaluated on a relative basis by rating each on its fulfillment of the desired characteristics. This method provides a means for ranking the systems which are considered in the order of their cost-effectiveness. It presupposes some knowledge of the desired characteristics; system standards, which are derived by assigning acceptable limits to the characteristics, are not required. The desired system characteristics and some system improvements and alternatives proposed by the work group are included in Appendix D; a typical decision matrix which might be utilized for the evaluation of the candidate alternate systems is shown in Appendix B. The output of the analysis will be recommendations for the directions of the R & D efforts in the field of river Aids to Navigation. The work group activities are scheduled for conclusion with a final report by September 1975. Additional details concerning the work group direction and scheduling may be found in the text of this report.

INTRODUCTION

The Swift-Running Rivers Work Group was formed as a part-time work group whose primary function is to develop an R&D approach to a long-term solution to navigation in swift-running rivers (see G-CBU/84 memo 5930 dtd 29 APR 1974 in Appendix A). The group consists of permanent representatives from G-WAN, G-DET and CCGD2 (oan); temporary members with expertise in specific areas of interest are requested as the need arises. Any one member of the work group is expected to spend about 20 percent of his time on work group business. The establishment of the work group was recommended in G-DET memo 3900, Ser 9867 dtd 21 MAY 1974 to G-WAN. G-WAN accepted the concept of the work group as outlined in the G-DET memo by G-WAN-2 memo 3900 dtd 20 JUNE 1974. Both of these memos are included in Appendix A.

The body of this report consists of three main sections: 1. The Problem, 2. The Direction of the Effort, and 3. Scheduling. These individual sections and the various Appendices should give the reader a good idea of the total situation at this time as viewed by the group collectively.

Note: The work group effort so far is concentrated in the Second Coast Guard District. The work group is aware that the Second Coast Guard District does not contain all of the swift running rivers in the United States. In fact, there are such rivers in the eighth and thirteenth districts. However, the majority are in the Second Coast Guard District; therefore, the group decided to concentrate its efforts there first.

DEFINITIONS

ANT - An Aids to Navigation Team is a highly mobile unit which performs only aids to navigation work, and which is usually composed of four to eight men highly trained in aids to navigation servicing. An ANT is usually equipped with a high-speed ANB (Aids to Navigation Boat), a trailerized boat, and vehicle(s). ANT's may use the facilities of any Coast Guard shore unit when servicing aids to navigation in the area of that unit, or the ANT may have its own shore facilities. A major advantage of ANT's is their ability to perform routine servicing of aids to navigation in an area, freeing larger aids to navigation units to do other work beyond the capabilities of the ANT.

Cost-effectiveness - As the term implies, the cost-effectiveness of a system is a measure of the effectiveness of the system in performing its designed task in light of its cost. System effectiveness relates to the degree of fulfillment of certain prescribed standards. In order for a system to be considered seriously for a particular task, it must meet the minimum acceptable level of effectiveness. The minimum acceptable level of effectiveness is a subjective limit set by those who will implement the system, e.g., a set of tentative operating requirements. If the system passes this first test, a descriptive cost factor (usually life-cycle cost) is calculated for the system. The results of the effectiveness and cost analyses are used in some suitable fashion, which may be peculiar to the particular evaluation, to compute the value of the comparative cost-effectiveness criterion (some form of cost/effectiveness or effectiveness/cost). Then the system which is the most cost-effective can be chosen from those being considered.

High water - High river level which, in general, implies the swiftest river current. The quantity of debris in the river usually peaks during high water periods due to an increase in river bank landslides and the collection of debris from flooded area. Often, the sleuce gates on dams in pooled rivers are opened completely during high water to avoid damage to the dam structure, essentially transforming the pooled river into an open river.

Low water - Opposite of high water.

Open river - These are rivers which flow freely; their path and flow rate are not controlled by dams. Their exceptionally swift current during periods of high water may cause unpredictable shifting channels; and, for this reason, buoy stations are not charted for open rivers. Consequently, training dikes may be constructed in them to keep the fast water near mid-river and, hopefully, to hold the channel there also.

Pooled river - These are rivers whose path and flow rate are altered by dams in order to enhance their navigability. In general, buoy stations are charted for these rivers. There are times during exceptionally high water when the balance of forces requires the maximum opening of the sleuce gates at the dams in order to protect the dam structures. During such periods, the river is essentially an open river.

Revetment - A paved portion of river bank which is designed to prevent bank landslides. Revetments vary in size and are constructed mainly in known problem areas.

River gauge - River gauges are located at various intervals along a river. They provide a base from which to measure the water level. However, each gauge does not measure necessarily the river level with respect to the same base. The state of the river level at any given time and the river level predictions are given in terms of a river gauge at a particular location.

Training dikes - Jetty-type structures constructed by the Corps of Engineers in the open rivers, or pooled rivers with exceptionally high flow rates during high water periods, to force the fastest current to mid-river. The purpose of the dikes is to stabilize the navigable channel as much as possible. They are constructed commonly of loose rock and wood piles, extending from the bank into the river.

I. The Problem

The Western River System, illustrated in fig. 1, is a 5000 mile network of navigable waterways which bears over 175 million tons of commerical cargo per year. The Coast Guard maintains an aids to navigation system, which includes approximately 10,000 unlighted river buoys and 3000 shore aids, to enhance navigation on the rivers. Many of the rivers, particularly the open rivers, present a unique hostile environment which, through a combination of forces, e. g., swift current, surface and sub-surface debris, and rapidly changing river gauge levels (see definitions section), greatly complicates the operational and economic problems in system maintenance. A concise statement of the problem is difficult, if not impossible. However, the apparent symptoms are listed as follows:

(a) Buoy losses throughout the Western River System average 53% per annum at this time. The most adverse conditions on the open rivers account for most of the losses. Buoy losses on the open rivers may exceed 100% per annum. The buoy loss problem reduces the reliability of the total system, as well as its overall cost-effectiveness. When buoys are continually off-station, the function of the aid system is undermined; and the cost of system maintenance increases greatly.

(b) The WLR class buoy tenders which service the aids to navigation on the open rivers may replace or reposition as many as 100 buoys during one eight-day patrol. In addition, they will retrieve stray buoys and service numerous shore aids. The duty cycle of the tenders is governed almost solely by the expected buoy losses. The employment schedule for the three tenders which service the Missouri River is eight days underway on AtoN patrol and five days in port (from April to December each year; the Missouri

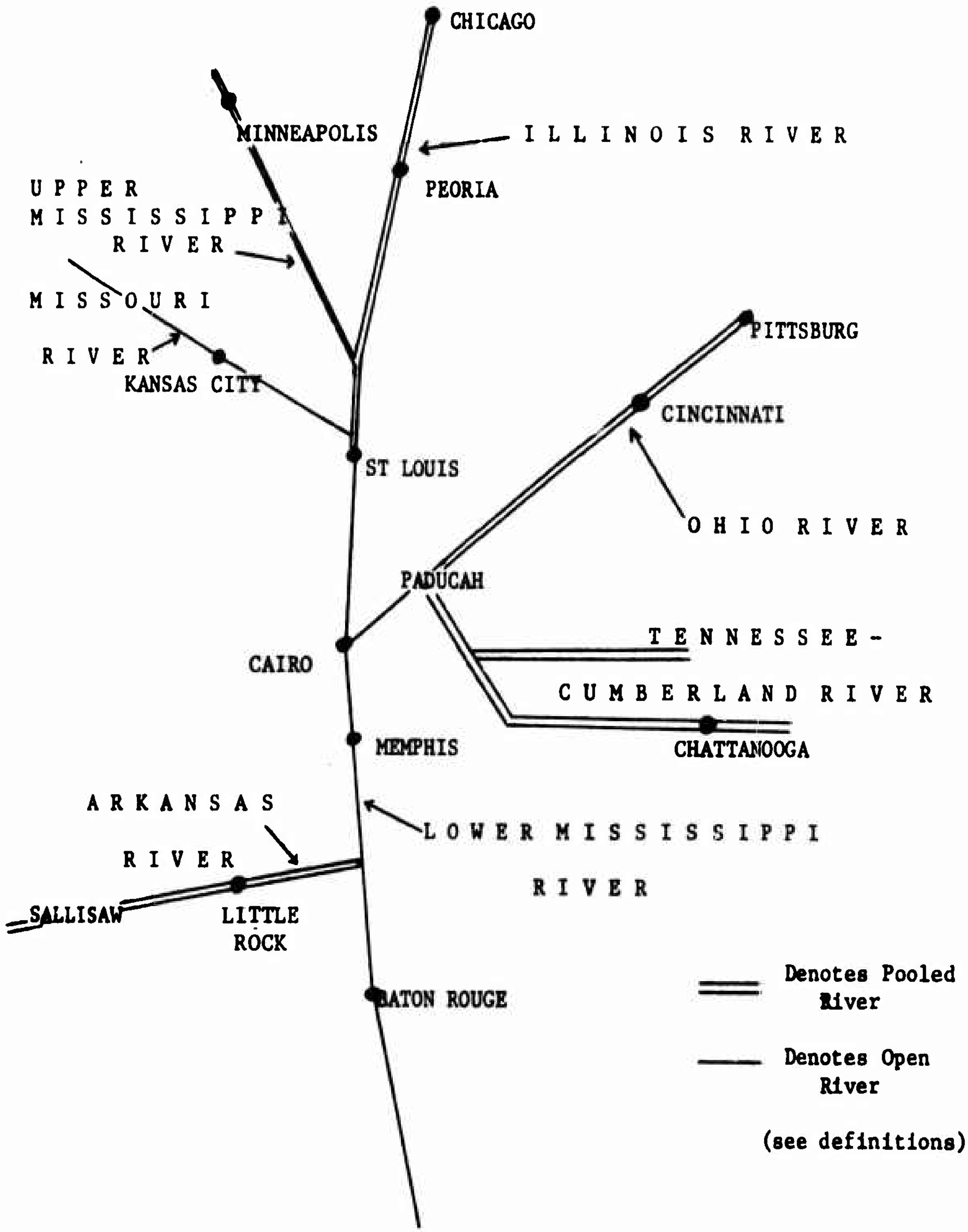

CHICAGO
MINNEAPOLIS
ILLINOIS RIVER
PEORIA
UPPER
MISSISSIPPI
RIVER
MISSOURI
RIVER
KANSAS CITY
PITTSBURG
CINCINNATI
ST LOUIS
OHIO RIVER
PADUCAH
TENNESSEE-
CUMBERLAND RIVER
CAIRO
MEMPHIS
CHATTANOOGA
ARKANSAS
RIVER
LOWER MISSISSIPPI
RIVER
SALLISAW
LITTLE
ROCK
BATON ROUGE
Denotes Pooled
River
Denotes Open
River
(see definitions)

Fig 1

is closed to traffic during the Winter months). Their crews have been augmented to permit a quasi "blue-gold" concept, i.e., two-thirds of the crew is aboard for any particular patrol. The tenders which service the Lower Mississippi River have a similar employment schedule, and the tow-boat industry is actively pressing for an increased patrol frequency on that open river. The work-load for the WLR's on the open rivers has become excessive. The alternatives within the present system are (1) to continue performing the tasks of the river tenders with too few vessels or (2) to increase the size of the present fleet of servicing vessels and redistribute the workload. The first option perpetuates the shortcomings of the present system, and the second requires increased procurement and/or outfitting funds (depending on the source of the vessels - new construction or recommissioning) and long-term maintenance funds. Neither option is very attractive.

(c) The maintenance of the present river AtoN system requires a constant supply of large quantities of buoys and moorings; consequently, the system is extremely vulnerable to changes in the economic climate. Recent inflation has reduced the purchasing power of AtoN funds. Buoy prices increased 40% in 1974 and wire rope costs are up 20-60%. The budgetary process does not allow for rapid increases in prices; under such conditions, the only alternative is to decrease service and overall responsiveness to the needs of the user until supplementary funds can be obtained. But the large consolidated tows transiting the Western Rivers nowadays require a high degree of navigational accuracy. The disparity between required and provided service is obvious.

The identification of these symptoms as true problems is premature since, at present, there is no mechanism for collecting and analyzing river buoy loss information for the determination of system performance. System studies are needed to determine:

(a) if the present level of buoy losses is excessive or merely a fact of life in the river environment

(b) if recurring buoy losses decrease the effectiveness of the system beyond acceptable limits

(c) if the cost of maintaining the present system is beyond acceptable limits

In fact, what are the desired standards for a river navaid system? Is it our objective to get a towboat and thirty barges from Minneapolis to Baton Rouge without a mishap, day and night, fair weather and foul, high and low water? Shall buoys be set to remain on-station 10% or 90% of the time? Shall we use a system which is marginally reliable and costs $1K per year to maintain or one which is 99% reliable and costs $100M a year? The direction of the work group effort to "develop an R&D approach to a long-term solution to navigation is swift-running rivers" is explained in the next section.

2. The Direction of the Effort

At this point we will assume that the present AtoN system on the Western Rivers does not provide the effective service which is required and that its maintenance costs are excessive. Consequently, the Coast Guard has initiated a search for system improvements or alternatives. We can evaluate any number of systems on a relative basis by rating each system on its fulfillment of some desired system characteristics. This method provides a means for ranking the systems which are considered in the order of their cost-effectiveness. It presupposes some knowledge of the desired system characteristics; however, systems standard, which are derived by assigning acceptable limits to the characteristics, are not required.

The general approach is to meld all possible solutions against the desired system characteristics of a river navaid system. Brainstorming sessions conducted during the first field trip (24-28 June 1974) yielded a list of possible alternate systems and system improvements and a list of generally desired system characteristics. These lists are included in Appendix D. However, the time constraint presently imposed upon the duration of work group activities precludes the consideration in depth of both cost and effectiveness characteristics. The "horse-before-the-cart" sequence of things dictates that the effectiveness characteristics should be the first order of business. Consequently, our primary effort will be concentrated in this area; cost characteristics will be considered as time permits.

An example of a typical decision matrix which might be utilized to evaluate the alternate systems for their effectiveness is shown in Appendix B.

The knowledge obtained from a serious research effort can be applied in such a matrix to produce reliable relative ratings of the different system improvements or alternatives for each characteristic. For the purposes of this study, the weighting factors used in the decision matrix reflect the consensus judgement of the work group. However, this does not limit the applicability of the method; weighting factors can be altered easily to meet changing philosophies within the Coast Guard.

The following features of the proposed work group approach are noteworthy:

a. The work group will attempt to offer realistic weighting factors for the effectiveness characteristics as well as suggested cost-effectiveness criteria. However, recommendations for further investigations will be made primarily on the results of the effectiveness studies since cost characteristics will not be considered in depth.

b. The effort should be divided into at least three phases. These Are:

1. Detailed orientation, systems research and data collection.
2. Data evaluation and correlation.
3. Report preparation and presentation.

Phase I was begun in October 1974 while the details of the work to be accomplished during Phases 2 and 3 were being discussed. The specific questions which must be answered during the research phase are listed in Appendix C; however, any member may suggest additions to the list at any time. The information obtained will be detailed clearly to permit the subsequent inclusion of pertinent facts in the analysis.

c. For data collection purposes, two rivers will be assigned to each of the work group members (LT Colburn will be the R&DC temporary representative). The river assignments are:

i.	Upper Mississippi Lower Mississippi (Memphis - Baton Rouge)	LT Colburn
ii.	Illinois Lower Mississippi (St. Louis - Memphis)	LT Ryan
iii.	Missouri Ohio	LT Tozzi
iv.	Arkansas Tennessee - Cumberland	CDR Drewer

The decision matrix analysis will be performed for each river individually (or even for different sections of the same river if the data indicates that further division is necessary). The members are aware of the possibility that different systems may be found most effective on different rivers. The characteristic of "system standardization" is designed to recognize the shortcomings of trying to use too many different systems.

Some tentative scheduling is suggested in the following section.

3. SCHEDULING

A general outline of work group activities through August 1975 follows:

3-4 October 1974 -	Group meeting to discuss any last-minute items before Phase 1 begins
October 1974 - April 1975 -	Conduct Phase 1 investigations
May - June 1975	Conduct Phase 2
July - August 1975	Conduct Phase 3

This schedule will be modified as necessary changes become apparent.

APPENDIX A

UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

G-CBU/84
5930

DATE: 29 APR 1974

SUBJECT: Review of Mississippi River System Navigation Problems

FROM : Chief of Staff

TO : Distribution

Ref : (a) G-CBU memo 5930 of 25 April 1974
(b) CCGD2 ltr 3[illegible] February 1974

1. Reference [illegible] a copy of which is enclosed for your information, outlines the recent meeting held by Senator McClellan regarding towboat service on the Arkansas River. Aside from the immediate problems associated with that portion of the whole Mississippi River system, the meeting identified a serious problem and unusual opportunity facing us. To address both the short and long-term implications, I would like the following actions to be taken:

a. G-W, in conjunction with G-E, is to develop a position to meet the immediate problems on the Arkansas River. At the same time, a response to reference (b) should be formulated. G-CPA and G-CBU are to assist in reprograming and FY 1976 budget actions which may be necessary to implement that position. These projects should be ready for my review by the close of business on 3 May.

b. G-D, in conjunction with G-W, is to develop an R&D approach to a long-term solution to navigation in swift running rivers. This approach should not be restricted to improved buoy design, but should include techniques considered where other precise navigation requirements have been examined. I would like to discuss the general approach to a long-term solution at the same time the short term solution is reviewed. A fully developed proposal will not be necessary for this purpose.

c. G-CC is to contact their counterparts in the Corps of Engineers and obtain statistical data presented at the 25 April meeting with Senator McClellan.

2. In view of Chairman McClellan's strong interest on this subject, both the short and long-term approaches are likely to be covered in detail during our Senate appropriation hearings. Therefore, a concerted effort is needed to be prepared for this eventuality.

E D Scheiderer

E. D. SCHEIDERER

Encl:
(1) Reference (a)

RCVD ... 24 1974 ... (944)

UNITED STATES GOVERNMENT

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Memorandum

G-DET-2
3900
Ser: 9867
DATE: 21 ... 1974

SUBJECT: Work Group to Study Long-Range Solutions to the A to N Problems in Swift-Running Rivers; Recommendation for the Establishment of

Cdr R

FROM : Chief, Environmental and Transportation Technology Division

TO : Chief, Aids to Navigation Division

REF : (a) G-CCS (G-CBU/84) memo 5930 dtd 29 April 1974

1. Reference (a) tasked G-D, in conjunction with G-W, to develop an R&D approach for a long-term solution to the A to N problems in swift-running rivers. It states further that the approach should not be limited to improved buoy design; the investigation should include techniques considered for other precise navigation systems.

2. The effective development of such an approach will depend upon the successful accomplishment of several work units. The general descriptions of the most prominent of these include the following:

a. Define and document the river environments including a specific grouping, if possible, of rivers with similar adverse current/debris conditions.

b. Study the present system effectiveness and adequacy on each river both for the Coast Guard and the user.

c. Evaluate the present R&D efforts in fast water buoy development for their potential usefulness in lights of the results of a and b above.

d. Evaluate other forms of precise navigation to determine their possible roles, if any, in the swift-running river environment.

e. Finally, develop an approach for future R&D based upon the results evaluation.

These work units are broken down even further in the Work Breakdown Structure included as enclosure (1).

3. The responsibility for the overall task has been assigned to G-DET-2. LT JOHN T. TOZZI of G-DET-2 has been nominated to coordinate the efforts of this branch. The initial task at hand is to establish a work group whose members have the expertise necessary to assist the effort through its completion. It is expected that one (1) person from each of the following activities will be required:

a. G-DET, G-WAN, CCGD2(oan)

b. CCGD2(ecv)

c. R&D Center, fast water buoy development personnel

d. G-M or supporting G-DST personnel concerned with maneuvering characteristics of tow boats on the Western Rivers.

e. G-DET, electronic navaid personnel

LT TOZZI and the designated G-WAN and CCGD2(oan) personnel will be the three permanent members of the group. Personnel from the other areas of expertise which are listed will be requested as they are deemed necessary, but the total number of active members should not exceed five (5) at any particular time. This will permit the most efficient use of the time and talents of each individual. It is imperative that the permanent members of the work group are able to attend all of the field trips and conferences which will be scheduled. The total effort should require no more than twelve (12) months for completion; individual members may need to devote about 20% of their time to work group activities while serving with the work group.

4. The first field trip for the work group to the second district is scheduled tentatively for the week of 23 June 1974. The expressed purpose of this visit is to familiarize the group members with the problems on the Western Rivers and to discuss concurrently the direction of future investigations. If time permits, the discussions may lead to the beginning of the fact-finding work required to accomplish work units a and b of paragraph 2.

5. It is requested that you assign one officer from G-WAN to serve as a permanent representative on the proposed work group. The only specific qualification required is prior service aboard a buoy tender. The preparation necessary to insure a successful field trip during the week of 23 June 1974 will include a thorough review of all available documentation (in G-WAN and G-DET) from previous studies and the formulation of specific questions to be answered during the trip.

WELehr

W. E. LEHR

Encl: (1) Work Breakdown Structure

Work Breakdown Structure

TASK: FAST WATER RIVER NAVIGATION

Identify the elements and concepts for the task.

1. System Description
    A. Environment
        Stable/not stable
        Seasonal variations
        Ice
        Flow rates
        Debris
        Unique aspects
    B. Present ATON System
        Resources identification
        System costs
        Servicing fleet capability
        Aids (floating, fixed, dike markers)
            Installation
            Population
            Capability
        Standards
            Establishment
            Positioning
            Disestablishment
        Maintenance
            Routine
            Standard
    C. Corps of Engineers Interface
        Waterways maintenance
        Standards
        Capabilities
        Plans

2. Operations Description
    A. Vessel operations
        Area
            Bounds
            Charting
        Day-night considerations
        Visibility considerations
    B. Vessel Definition
        Types
        Population
        Maneuvering characteristics
        Limitations
        Navigation methods
        Installed nav/comms equipment

C. Traffic
   Distribution
   Flow patterns
   Terminals
   Regulations
   Local operating procedures
   System capacity
   Future operational needs
D. User Needs
   Navigational information requirements
   Other vessel information
   Waterway status
   User capability

3. Problem Definition
   A. Failures Identification
      Standards
      Types
      Detection
      Reporting
      Correction
   B. Failures Correction
      Time
      Costs
      Methods
   C. Failures Analysis
      Types of failures
         Environmental
         Collisions
         Debris
      Costs
      Geographical uniqueness
      Tradeoffs
         Economic
         Legislative
         Operational
         Technical
         Human factors

4. Short Range Candidate Solutions
   A. Non-buoy
      Operational
      Shore/ground based aids
   B. Buoy Solutions
      Decrease loss rate
         Larger buoys
         Mix of buoys
      Decrease number of buoys
         Fewer larger buoys
         Non-buoy augmentation
         Mix of buoys

!. Long Range Candidate Solutions

A. Buoy Solutions
- Improved-augmented present buoy
- New family of fast-water buoy
  - System standards
  - R&D technical project (underway)

B. Non-buoy Solutions
- Legislative
- Operational
- Electronic navigation system
  - Area
  - Critical point
- Follow the wire
- Acoustic systems
- Innovative shore aids
- Improved vessel equipment
- COE waterway improvements
- Improved information system
  - Flow rates
  - Depths
  - Congestion
- Vessel traffic system establishment
  - Critical points
  - Queneing
  - Traffic control

UNITED STATES GOVERNMENT

Memorandum

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

G-WAN-2
3900

DATE 20 JUN 1974

SUBJECT: Work Group to Study Long-Range Solutions to the ATON Problems in Swift - Running Rivers

FROM : Chief, Aids to Navigation Division

TO : Chief, Environmental and Transportation Technology Division

Ref : (a) G-DET-2 memo 3900 Ser 9867 of 21 MAY 1974

1. CDR John D. DREWER (6470) 224 52 5395 USCG, of Systems and Facilities Branch of this Division will represent G-WAN for the purposes of subject Group.

2. It is requested that orders and funding connected with CDR DREWER's travel with the Group be issued and borne by your Division.

V. R. ROBILLARD
Acting

APPENDIX B

Characteristics / Weighting Factors / Alternate Systems	Flexibility WF	Durability WF	Vulnerability WF	Maintainability WF	Reliability WF	Suitability WF	Acceptability WF	Simplicity WF	Standardization WF
Electronic Systems Total-	rating rating x WF								
Follow-the-Wire Total-									
Underwater Acoustic Total-									
Bottom Profile System Total-									
Moored Weather Balloons Total-									
VTS Total-									
Hang Channel Markers Overhead Total-									

Method: (1) relative ratings placed in upper part of box
(2) relative rating multiplied by weighting factor placed in lower part of box
(3) Total of (2) for all systems calculated; highest or lowest score may win depending on definition

APPENDIX C

PHASE I GUIDE

River________________________ Mile____________ to Mile__________

Aids to Navigation Patrol Vessel____________________________________

Group to which assigned____

COE District_____________________ Mile____________ to Mile__________

_____________________ Mile____________ to Mile__________

MSO Responsible__________________ Mile____________ to Mile__________

__________________ Mile____________ to Mile__________

Other Federal Agencies, if any______________________________________

State Agencies with responsibilities on this section of River________________

____

Commerical Pilot, Towboat Operator, Maritime, etc., Associations based on this

section of River____

____

I. Of CG personnel (district, group, MSO, depot, tender):

A. How well does our present A to N system work in this section of the river?

1. How many buoys were lost in this section in each of the last 5 years?

a. Of buoys lost, how many are recovered?

b. Can buoys recovered be identified with the aid station from which they were lost?

c. How many buoys recovered are undamaged?

d. How many buoys recovered have their moorings intact?

e. How many buoys recovered show evidence to indicate why they are adrift?

f. How often are buoys lost due to obvious towboat collisions?

g. Indentify: High loss times and areas, buoy station density, other reasons for buoy losses.

2. What is the A to N Patrol Cycle required by Annex K, CCGD2 OPLAN for this section of the River?

a. What is the basis for this particular cycle being established?

b. Unit logs for 1973 and 1974 should be aboard. From these, determine the actual patrol cycle of the tender. Review the [illegible] clues to other A to N problem areas. (If channel report files are kept aboard, the number of A to N patrols may be obtained from these files if COE patrols are discounted).

c What appears to be the most realistic cycle for A to N patrol in this section of the River?

d. How often are adjustments to aids required for shifting channels?

3. Comment on vessel personnel allowance:

a. Allowance versus personnel actually assigned.

b. Adequacy of allowance. What is minimum allowance to operate?

c. What watchstanders are required underway?

d. How great is the retention of experienced "river sailors" in CGD2, in the CG?

e. Experience level of each person attached?

4. Any safety problems in the way the aids are tended?

5. What problems have been experienced with shore aids/buoys in this section of the River?

6. How many buoys does the tender have on station in this section of River at any given time?
   a. How many of these buoy stations do the tenders consider "permanent" (don't have to relocate the buoy frequently)?
   b. What percentage of the buoys in this area are worked during each A to N patrol?
7. Have all potential applications of fixed structures (to replace buoys) been considered in this section of River?
8. What is the philosophy of the tender in marking this section of the River?
   a. What do they mark and why?
   b. Do they use "courtesy" buoys (buoys which mark no danger but just fill in between other buoys)?
9. Does the tender jet buoy moorings in this section of the River? If not, why?
10. What is the tender's philosophy as to scope of mooring used? Are all the tender's buoy moorings the same length?
11. Is the tender design suitable for its task?

B. What ideas are there for improved systems on this section of the River? Electronics, all shore aids, etc.

C. What is the maximum current on this particular river? Where does this maximum current occur? Maximum rise and fall of the river?

D. Is debris a problem on this section of the River?

E. Is this section of the River typically open or pooled?

F. How have river conditions in the last 2-3 years compared to previous years?

G. How much does the channel really shift?

H. How reliable are the river predictions received on this particular river-where do they come from?

I. What kind of coordination exists between the CG and the Corps of Engineers on this section of the River? What coordination improvements are indicated?

J. Have tender skippers actually been performing and reporting semi-annual inspection of aids while riding commercial tows, as required by CGD2 OPLAN, Annex K?

K. How many river pilots/COE Resident Engineers and/or other COE personnel on this section of the River do the tender skipper/Executive Petty Officer know by name?

L. G-PE is making a special effort to retain River tender experience by transferring experienced river tender skippers to Deputy GRUCOM jobs. How much of the DEPGRUCOM's time is spent in liaison between pilots, CofE, and river tenders? Does GRUCOM or his deputy go to meetings of commercial operator organizations in his area? Does tender skipper or his XPO make any effort here?

M. What problems, if any, do Coast Guard personnel experience with River Pilots? With CofE personnel? Are communications/relations between the three (CG-CofE Operators) good? If not, what can be done to improve them?

N. Is the AtoN effectiveness of the unit affected by its collateral duties, e. g., SAR, etc?

II. Of Corps of Engineers (District and Resident Engineers):

A. In their opinions, how well does the present navaid system work on this section of the River?

B. What improvements can be made to present system?

C. What ideas are there for new, different systems?

D. What support facilities for physical help and/or information does the Army maintain in the area which could be helpful to the Coast Guard District, Group, and/or tender personnel?

E. How about better coordination between Coast Guard/Corps - possible or necessary?

F. What facilities does CofE have in this river to maintain/relocate buoys?

G. How many CG Group Commanders/DepGruCom/Tender skippers do CofE personnel interviewed know by name? How often are they visited and/or contacted by Group or Tender personnel?

H. Do CofE lock and dam personnel call CG tender skippers downriver as soon as they foresee having to fully open the sleuce gates (running partial or full open river)?

I. Lower Mississippi River - CofE comment on CG assumption of buoyage previously accomplished by CofE.

J. Does CofE think they can do a better job of river buoyage than CG? If so, what makes them think they can?

III. Of Commerical Towboat Operators:

A. What navigation aids do they <u>need</u> to safely navigate this section of the River?

1. What physical characteristics of the River concern them?
2. What do they expect from navigational aids:
    a. Buoy hopping
    b. Marking of submerged dangers (buoys or fixed aids) or Marking of a course to steer through the dangers (shore "ranges")
    c. Other
3. What do they think of the present navaid system?
4. Are there any complaints on the present system or its maintenance? If so, what improvements would they like to see?
5. Is buoy shape critical, or just color - or neither?

6. Could they safely navigate this section of River with fewer aids?
7. Do they consider maintenance of the present system as critical?
8. Complaints have been received at Headquarters that some towboat operators feel aids are not serviced frequently enough. Do commerical towboat operators on this section of the River share this view? If so, why do they feel this way?

B. Have towboat operators noticed any difference in the way the various tenders mark their sections of the River?

C. Do towboat operators operate at night? If so, do they rely on their RADAR or their searchlight for navigating this section of the River? If both, which do they rely on primarily?

D. Does the operator know either the GRUCOM/DEPGRUCOM, tender skipper/XPO, and/or MSO(s) on this section of the River by name? When was the last time any CG personnel asked to ride with him on a trip through this section of the River?

E. How would the operators receive a radically different system, e. g., electronics or other?

F. What commerical or private organizations does the operator look to for assistance when he has a problem on the River?

G. Is the pilot under pressure from his company to carry more barges than he feels he can handle?

H. Ask the pilot/operator to comment on the Channel Report for this section of the River. Does he use it? If so, how could it be improved (radio reports, telephone recordings he could call, changes only, etc.). If not, why?

I. How long has he been a towboat operator?

APPENDIX D

I. POSSIBLE ALTERNATE SYSTEMS OR SYSTEM IMPROVEMENTS

A. Alternate Systems

1. Electronic system, e.g., LORAN-C, range-range positioning, OMEGA, ect.
2. Follow-the-wire (magnetic navigation system).
3. Underwater acoustic.
4. Bottom profile system which displays the river bottom ahead of the tow.
5. VTS
6. Hang channel markers from wires strung overhead.

B. Improvements Affecting AtoN Equipment

7. More expendable buoys
8. More sturdy buoys
9. Two-station, portable ranges ashore
10. Single-station ranges ashore
11. Total conversion to fixed structures
12. Active debris-shedding system on the buoys
13. Enhance the recovery of buoys by some means, e.g., echo-sounder attached to buoy, etc.
14. Stronger and/or more expendable mooring systems

C. Improvements Affecting CG Vessels and Personnel

15. Increased CG AtoN Patrols
16. Short-term monitoring of system discrepancies by high speed water-craft or aircraft to provide aerial photos, depth-sounding charts, etc.
17. Use high-speed watercraft for servicing the AtoN system

18. Complete implementation of the ANT concept
19. Mark the 6 foot contour in lieu of the 9' contour to keep the towboats away from the buoys
20. Require all CO's and OinC's to be licensed pilots in their section of the river
21. Permit or encourage "homesteading" on river tenders
22. Incentive pay for the river tender personnel
23. Increase tender crew sizes and/or upgrade the billets
24. Establish a detailer specifically for river tender personnel, who will coordinate all transfers to and from tenders
25. Periodically rotate depot and tender personnel to permit some shore duty for all
26. Dedicate buoy tenders to AtoN work only - no collateral duties
27. Keep experienced tender personnel on the boats but rotate them frequently (at least once each 3 years) to different boats on different rivers
28. Improve the habitability of the present buoy tenders

D. Improvements Affecting Commerical Tows and Pilots

29. Exert more strict control over pilot qualifications before and after licensing
30. Require minimum standards on the size, draft, and/or maneuverability of tows

II. <u>DESIRED RIVER NAVAID SYSTEM CHARACTERISTICS</u>

A. Characteristics Related to Effectiveness

1. Flexibility
   a. To adjust for shifting channels
   b. To adjust for changing water levels

   c. To adjust for darkness and varying weather conditions

2. Durability
   a. To survive or avoid high current and/or debris
   b. To survive or avoid towboat collisions
   c. To survive ice conditions
3. Vulnerability
   a. To vandalism
   b. To the hazards of 2. above
4. Maintainability
   a. Type/size of servicing craft
   b. Frequency of required service
5. Reliability
   a. Accuracy
   b. Percentage of time available to the user, e.g., usable time for LORAN systems
6. Suitability
   a. For the channel-marking application in the river environment
   b. In providing the required information for safe navigation, e.g., sufficient information upon which to predict upcoming hazards to navigation
7. Acceptability to CG
   a. Safety
   b. Ease of procurement
8. Acceptability to user
   a. Ease of procurement
   b. Simplicity of use
9. System standardization

B. Characteristics Related to Cost

10. Life-cycle cost (CG and User)

a. Initial cost

b. Maintenance costs

c. Other related costs